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SITING CRITERIA DEVELOPMENT FOR LOW-LEVEL RADIOACTIVE WASTE FACILITIES

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SITING CRITERIA DEVELOPMENT FOR LOW-LEVEL RADIOACTIVE WASTE FACILITIES

INTRODUCTION

Derivation of siting criteria is the first step in a long and involved siting process. This report was prepared by Roy F. Weston, Inc. (WESTON) for the Massachusetts Health Research Institute (MHRI) and the Massachusetts Executive Office of Environmental Affairs (EOEA) to provide a list of siting criteria which could be utilized for low-level radioactive waste (LLRW) management facilities. It must be noted that the contract did not permit WESTON to consider the following related topics:

- Type of facility and alternative methods of disposal
- Siting process including ranking and application of criteria
- Specific type and availability of data for the siting process
- Standards for design, operation, closure and post-closure care of the site.
- Waste characteristics and disposal form
- Monitoring and surveillance
- Financial assurances.

Each of these efforts are presently being addressed separately in independent efforts in conjunction with the Massachusetts Special Legislative Commission on Low-Level Radioactive Waste and the EOEA.

The derivation of siting criteria is not a new process. There is extensive literature on the topic of siting. As the potential regulator, the Nuclear Regulatory Commission (NRC) has printed many reports on the siting of LLRW facilities. These reports are in the "NUREG" series and can be obtained from the NRC/GPO Sales Program, U.S. Nuclear Regulatory Commission, Washington, DC 20555. A number of states have derived siting criteria for LLRW facilities. Furthermore, there have been literally hundreds of reports on private and public efforts to derive siting criteria for hazardous waste facilities and other facilities viewed as undesirable by the public (e.g., prisons, municipal landfills, power plants, etc.). This literature base will be discussed in more detail later in this report.

Previous siting criteria development efforts have suffered from several major shortcomings as follows:

- Public rarely has direct input in derivation of siting criteria - typically only involved in public comment period

- Incomplete literature searches due to diversity of literature involved in the different social science, scientific, political, and engineering fields which are involved as well as the different types of facilities which were to be the focus of the siting process

- Confusion over terminology used in the literature (e.g., criteria, factors, elements, suitability requirements, etc.) and the difficulties of using the jargon of various disciplines involved in the siting process as well as confusion over the siting process itself.

WESTON has attempted to address each of these concerns in the sections below, before the actual siting criteria are described.

PUBLIC INPUT PROCESS

WESTON wanted to maximize public input into its development of the siting criteria. This desire for input is different than soliciting public comment on criteria derived by consultants working solely with the general literature and local "expertise". By using professionally facilitated small group sessions, criteria development could be discussed interactively by the public representing all sides of this siting issue. The recorded "group memory" could then be used by WESTON to help depict the siting criteria.

Because of the severe time constraints imposed on WESTON, only four sessions could be scheduled. The locations were selected to maximize geographical input. Four meetings were scheduled for three days. The meetings were held as follows:

Pittsfield..... March 19, 1984
Amherst..... March 20, 1984
Boston (afternoon)... March 21, 1984
Boston (evening)..... March 21, 1984

WESTON wanted to schedule meetings in Worcester, Southeastern Massachusetts and Northeastern Massachusetts. However, the fast track approach used by WESTON made this impossible. WESTON did, however, attract participants from these areas to the Boston meeting.

The EOEA provided WESTON with a mailing list of individuals who should be invited to attend. Because the facilitated groups must be kept small in size (i.e., generally 12 people or less), the mailing list had to be kept small. WESTON supplemented the list received with the assistance of the Legislative Commission on Low-Level Radioactive Waste, the Massachusetts Nuclear Regulatory Referendum Campaign and NELRAD (see Appendix I). Invitations were sent approximately three weeks prior to the session with an RSVP request. Extensive telephone follow-up activity was utilized to insure active participation and group balance of interest.

WESTON selected an independent professional facilitator to conduct the sessions. Dr. Merle Lefkoff was retained to conduct the sessions and provide the recorded group memory. Dr. Lefkoff brought a wealth of experience to these sessions. Evaluative comments received from the session participants seemed to be indicative of her skills and sensitivity to their input. WESTON participated in each session in the role of a group member.

Each participant was mailed the transcript of the session they attended. They were asked to examine it and share it with their colleagues. The report deadline did not make it possible to include these comments here. However, WESTON will provide the contractor with an addendum if these comments are extensive. Those people who could not attend a session were mailed the transcript of the session that they would have attended. They were provided with the same opportunity to comment. All the transcripts are included in this report (See Appendix II).

LITERATURE SEARCH

In an effort parallel to the development of the public input process, WESTON was conducting an extensive literature search on the topic of siting criteria. This literature falls into one of three general categories:

- Nuclear Regulatory Commission Literature
- State low-level radioactive waste facility siting literature
- General literature on low-level radioactive waste, hazardous waste, and other facility siting

WESTON searched the literature in several ways. Because WESTON has been involved as a consultant in a large number of siting efforts in the past, it has a substantial siting literature base. Several members of the project team have been specifically involved in siting criteria development for low-level radioactive

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waste management facilities. The project director visited with each of these individuals to see that the proper literature was secured for the report preparation. Members of the public who participated in WESTON's unique public input process were asked if they had any further literature inputs. Finally, a computerized literature search was conducted to make sure we did not miss any important documents.

Of the hundreds of documents identified in this extensive literature search, WESTON chose to utilize the references cited

in Table 1 as its primary information sources for this report. These reports represent the regulatory process, local concerns, and the specific focus of the LLRW facility siting problems.

CONFUSION

As a result of the WESTON public input process, several serious areas of confusion became apparent. Three major sources of confusion are as follows:

- Terminology and language
- Overlapping of related processes which the EOEA and NRC have chosen to treat separately (e.g., siting, design alternatives, operations, closure, monitoring, etc.)
- Status of the siting process in Massachusetts

Each of these items will be discussed below.

The siting process has derived its own very specialized language. This language, which is specific to each of the many technical disciplines involved, serves an important function in that it allows precise communication among practitioners. Even when used in the manner for which it was created, the very nature of this language serves to confuse the general public. The result is often that there is no common language. Consensus based on mutual understanding is nearly impossible to attain.

An example of poor communication can be found in the award of the "1979 Doublespeak Award"* to the Nuclear Regulatory Commission

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*R. J. Smith, Science, 206, 1163 (1979)

(NRC) for its explantions during the Three Mile Island incident. (Figure 1). These examples confuse the public and further erode the credibility of the people who use them. The language of the NRC siting regulations (10 CFR Part 61.50) may not be quite as bad; but certainly leads to further confusion with other terms used interchangeably in the siting literature. Terms utilized include the following: criteria, factors, characteristics, elements, technical requirements, suitability requirements and features.

FIGURE 1. NRC DOUBLE SPEAK

Explosion = energetic disassembly

Fire = rapid oxidation

Accident = normal aberration of plant transient

The Reactor Vessel is Contaminated with Plutonium	=	plutonium has taken up residence in the reactor vessel.

A criterion is defined by WEBSTER's as "a standard on which a judgement or decision may be based." The criteria are conceptual rather than operational, since a criterion states that an item must be examined, but it does not state how it should be examined. In order to use the siting criteria, a means must be used to assign units to each criterion that can be effectively measuresd and eventually weighed against one another. Each criterion can be constructed with different pieces of information which can be called "factors". Factors do not answer any questions about the site. For example, having ten permeability readings do not in themselves tell whether the site is hydrogeologically "secure". Any particular factor may be used to help measure several separate criteria and may serve in a positive mode in one instance and a negative mode in another instance. This distinction will be examined in more detail later in this report.

Certainly the type of facility selected for LLRW management will profoundly influence the type of siting criteria which are used in the siting process. There may be the "chicken and the egg" philosophy involved in whether one chooses a very good site then selects the technology or whether one chooses the technology and

chooses a very good site to accommodate it. The discussion of alternative technologies is presently taking place outside this contract and to some extent without significant public input.

Most of the LLRW siting criteria have been derived for shallow land burial. On one hand, one might argue that this represents a worst case and, generically, the criteria would depict a valid means for dealing with any LLRW facility type. On the other hand, there is very serious public opposition to shallow land burial in Massachusetts and this opposition resents any mention of this terminology even for such a scenario. Many of the facilitated group meetings arranged by WESTON had difficulty separating the development of siting criteria from discussion of design information. The neat and convenient technical separation of siting and design in the NRC literature is not viewed comfortably by the public. They feel that these issues need to be discussed concurrently and that there should be significant and meaningful public input into the decision making process at a very early stage. Small group facilitated meetings may provide the best means of accomplishing this input.
Finally, there is some confusion in the public's mind as to how the siting process will proceed in Massachusetts. Certainly the development of siting criteria and the selection of a favored LLRW technology are the very first steps in the process. The EOEA has established an extensive statewide public participation program. Numerous and frequent meetings with groups from all over the State on this issue have been held and more are planned. As this process progresses and the Governor decides how Massachusetts will proceed, this confusion may be significantly reduced.

NRC SITING CRITERIA

The NRC has a regulatory process in place for dealing with low-level radioactive waste management. Unfortunately, the regulation in its present form only addresses options for "near surface disposal". New regulations will have to be added to cover alternative facilities. Discussion of this NRC regulation in this report does not constitute endorsement of the disposal option described. The EOEA is addressing this question in another study. The regulation, 10 CFR Part 61, specified licensing procedures, performance objectives, and minimum technical requirements in the subject areas of site stability, site design, facility operations, site closure, environmental monitoring, waste classification, waste characteristics, waste labeling, land ownership, and institutional controls. In addition, the regulation establishes requirements on financial assurances, participation by state governments and Indian tribes, records, reports, tests, and inspections.

With exception of new requirements on waste generators who will be transferring wastes for disposal, the effective date for Part 61 was January 26, 1983. Since that date, the licensing mechanism, performance objectives, and technical requirements for any new low-level radioactive waste disposal facility have been in-place.

Part 61 is directly applicable to any new land disposal facility licensed by the NRC. For any new land disposal facility licensed by an Agreement State, the State must have comparable health and safety standards.

At the present time, the Commonwealth of Massachusetts is not an "Agreement State" with the NRC. This means that the NRC will have to oversee the siting process with the regulations cited above. They are not authorized to license against any additional siting criteria. Even if Massachusetts were to successfully pursue a "Limited Agreement" for low-level radioactive waste with the NRC, it would still have to demonstrate that its siting criteria are at least as stringent as those in the NRC regulations. Any siting criteria which do not fit into the ten NRC categories will require special justification both for NRC review and to hold up to legal challenges here in Massachusetts.

All the various requirements found in Part 61 are held together by the need to meet four performance objectives. These objectives are listed in Table 2. The ability of the NRC siting criteria to meet these performance objectives can be described by the four key aspects of site suitability listed in Table 3. Finally, the relationship between the key aspects and the ten NRC siting criteria (discussed individually below) are depicted in Figure 2. This material is reproduced from some of the NRC literature to show some of the thinking that went into the criteria. The reader is referred to NUREG/CP-0028 for more details.

WESTON has provided lists of the NRC siting criteria to members of the facilitated groups. Many of these people had never seen the listing before. Nearly all the people examining the list for the first time had trouble understanding what the NRC meant by each criterion. The discussion below was taken from NUREG-0902 to provide some flavor in this report for the NRC criteria.

FIGURE 2. Correlation Between Key Aspects and Site Suitability Criteria (NUREG/CP 0028)

CRITERIA FROM § 61.50	ELIMINATE CONTACT WITH WATER	ASSURE LONG-TERM STABILITY	IMPROVE CONFIDENCE IN PREDICTABILITY	PROTECT THE INTRUDER
1			X	
2		X	X	X
3		X	X	X
4	X	X		
5	X	X		
6	X		X	
7	X		X	
8		X	X	
9		X	X	
10			X	

1. The disposal site shall be capable of being characterized, modeled, analyzed and monitored.

   This requirement implies that the proposed site should be geologically and hydrologically simple. Since site characterization investigations can sample only a small fraction of the surface area or subsurface volume of the disposal site, site characteristics must be such that these limited investigations can adequately define the site characteristics spatially across the disposal site. Site conditions should be such that well-documented analytical solutions or computer codes are available and applicable for modeling site performance. As a minimum, the modeling of site characteristics, such as infiltration or groundwater flow, should be able to reproduce natural steady-state conditions and perturbed conditions, such as responses to precipitation or stresses introduced by pumping during the site characterization investigations.

   Since most modeling tends to homogenize the hydrogeologic units and average the hydrologic properties for such units, the site characteristics should vary within a sufficiently narrow range so that the input to the modeling is representative of the hydrogeologic units and the assumptions underlying the modeling are valid. For example, the hydrogeologic unit used for disposal should not have continuous permeable or impermeable anomolies such as faults or fracture zones, sand lenses, weathered horizons, or karstic features that provide preferential pathways for or barriers to ground water flow.

   Furthermore, this requirement also implies that natural processes affecting the disposal site should be occuring at a consistent and definable rate such that the modeling of the site will represent both present and anticipatable site conditions after closure. Finally, since monitoring programs can sample only a small fraction of the surface area or subsurface volume or the disposal site, site characteristics must be such that the small number of monitoring points can adequately describe the extent to which radionuclides have migrated from the waste disposal units.

2. Within the region or state where the facility is to be located, a disposal site should be selected so that projected population growth and future developments are not likely to affect the ability of the disposal facility to meet the NRC performance objectives.

   This second requirement is tied to the potential for eventual use of the site. Disposal sites should be located in an area which has low population density and limited population growth potential. Disposal sites should be at least two kilometers from the property limits of the closest population centers. Consideration should be given to the potential for future land use activities, such as residential, industrial, agricultural, and recreational development, that could adversely affect the disposal site. The consideration of future land use for the site and surrounding vicinity should include limitations imposed as conditions of land ownership and zoning restrictions.

3. Areas must be avoided having economically significant natural resources which, if exploited, would result in failure to meet the NRC performance objectives.

   This requirement includes such resources as mineral, coal or hydrocarbon deposits, geothermal energy sources, timber and water resources. The requirement applies to resource recovery that may occur at the ground surface, in the hydrogeologic units used for disposal and isolation, and at greater depths which require excavation or drilling through the disposal units. Potential indirect effects caused by nearby exploitation, such as increased infiltration rates or steepened hydraulic gradients, should also be evaluated. The primary concerns with respect to the presence of exploitable natural resources are the likelihood of inadvertent intrusion by a resource exploiter and the effects of resource development on the performance of the site after the period of active institutional control.

4. The site must be generally well drained and free of areas of flooding or frequent ponding. Waste disposal shall not take place in a 100-year floodplain, coastal high-hazard area or wetland.

   This requirement consists of two components. The first component, related to drainage crossing the disposal site, primarily applies to the disposal site after construction of the near-surface disposal facility. However, natural areas of poor drainage or frequent ponding can be indicative of seasonally high groundwater levels and should be so noted by the applicant. In addition, areas of flash flooding, such as arroyos or dry washes, should be avoided. The second component, related to avoidance of the 100-year floodplain, coastal high-hazard area or wetland, implements Executive Order 11988, FLOODPLAIN MANAGEMENT GUIDELINES. This requirement can be applied to the disposal site at the site selection phase.

   The 100-year floodplain is defined in the Executive Order as the lowland and relatively flat areas adjoining inland and coastal waters, including flood prone areas of offshore islands including, at a minimum, that area subject to a one percent or greater chance of flooding in any given year. A coastal high-hazard area is defined as the area subject to high velocity waters including, but not limited to, hurricane wave wash or tsunamis. Wetlands are defined as those areas that are inundated or saturated by surface water or ground water at a frequency and a duration sufficient to support and, under normal circumstances do, or would, support a prevalence of vegetation or aquatic life that requires saturated or seasonally-saturated soil conditions for growth and reproduction. Wetlands generally include swamps, tidal flats, marshes, bogs, and similar areas.

5. Upstream drainage areas must be minimized to decrease the amount of runoff which could erode or innundate waste disposal units.

   This requirement can be applied to the site at the site selection phase. The NRC claims that it would consider engineering modifications or diversion of natural drainage to lessen potential impacts of the

upstream drainage area if these changes are long-term (equivalent to the duration of the radiological hazard) and will not require ongoing active maintenance. The NRC anticipates that diversions of perennial streams would not, in most cases, be acceptable. The consideration of upstream drainage areas should include the impact of potential modifications by others to the upstream drainage area, such a land clearing and cultivation or development of roads, which may occur after the near-surface disposal facility is in operation.

6. The disposal site must provide sufficient depth to the water table that groundwater intrusion, perennial or otherwise, into the waste will not occur. The NRC will consider exceptions to this requirement if it can be conclusively shown that disposal site characteristics will result in diffusion being the predominant means of radionuclide movement and the rate of movement will result in the NRC performance objectives being met.

   This requirement indicates that, with few exceptions, near-surface disposal of low-level radioactive wastes will be in unsaturated soil deposits (regolith). Exceptions could include dry disposal in engineered facilities or structures either completely below, partially below, or completely above natural site grade. Alternatively, as indicated in the wording of the requirement, waste disposal may be below the water table at some sites if it can be conclusively shown that site characteristics will result in molecular diffusion being the predominant means of radionuclide movement and the rate of movement will result in the performance objectives being met. In no case, however, should waste disposal occur within the zone marked by fluctuations of the water table.

   At sites where disposal will be above the water table, seasonal fluctuations of the water table and capillary fringe both prior and subsequent to waste disposal must be considered. The bottoms of the disposal units must be, at all times, above the saturated zone in order to limit the water contacting the wastes to that small portion which infiltrates through covers in disposal areas. Reducing the contact time of the water with the

waste by using freely-draining granular backfill should be considered. In addition, the accumulation of water in the disposal unit (bathtub effect) must be avoided. This can normally be accomplished if the bottom of the disposal unit can drain at least as readily as water can infiltrate into the disposal unit through the cover or sides and if there is no capillary rise of water into the disposal units from the underlying soil deposits.

For sites where disposal will be below the water table, the hydrogeologic unit used for disposal should have hydraulic properties, e.g., hydraulic conductivity and effective porosity, which essentially preclude groundwater flow. The hydraulic conductivity, as tested in-situ, should typically be less than 10 to the minus 6 cm/sec. The effective porosity would be expected to be on the order of 0.01. The hydrogeologic units which meet these conditions generally cannot be tested by normal techniques requiring addition or withdrawal of water in wells. Methods of determining that molecular diffusion is the prevalent mechanism of solute transport include age-dating of groundwater by isotopic ratios and radioisotopic methods to show that there has been no active circulation of groundwater within the unit during the length of time determined by the age-dating.

7. Any groundwater discharge to the surface within the disposal site must not originate within the hydrogeologic unit used for disposal.

This requirement stipulates that the hydrogeologic unit used for disposal will not discharge groundwater to the ground surface within the disposal site. Surface-water features sustained by groundwater discharge, such a perennial and ephemeral streams, springs, seeps, swamps, marshes, and bogs, should not be present at the proposed disposal site. This requirement will result in a travel time for most dissolved radionuclides at least equal to the travel time of the groundwater from the disposal area to the site boundary. In addition, this requirement should provide sufficient space within

the buffer zone to implement remedial measures, if needed, to control releases of radionuclides before discharge to the ground surface or migration from the disposal site.

Longitudinal dispersion may result in arrival of a few dissolved radionuclides at a point of interest earlier than calculated solely on the basis of groundwater travel time. However, for many radionuclides, the travel time should be longer due to retardation processes.

The NRC prefers long flow paths from the disposal site to the point of groundwater discharge in order to increase the amount of decay of the radionuclides, increase the hydrodynamic dispersion within the acquifer, and increase the likelihood of retardation of reactive radionuclides in the aquifer. In reviewing licensing applications, the NRC will rely primarily on radionuclide decay and secondarily on hydrodynamic dispersion within the aquifer to determine if estimated concentrations will be less than the acceptable limits. Retardation processes will be used as a margin of safety to offset the uncertainty in the data and analyses. However, the applicant may propose to consider each of the processes. The degree of reliance placed by the applicant on each of the three processes should be reflected in the methods of testing used during the site characterization investigations.

8. Areas must be avoided where tectonic processes such as faulting, folding, seismic activity, or vulcanism may occur with such frequency and extent to significantly affect the ability of the disposal site to meet the NRC performance objectives or may preclude defensible modeling and prediction of long-term impacts.

   This requirement relates to the stability of the disposal site. The site must have the ability to isolate low-level radioactive wastes for the duration of the radiological hazard (approximately 500 years).

9. Areas must be avoided where surface geologic processes as mass wasting, erosion, slumping, landsliding, or weathering occur with such frequency and extent to significantly affect the ability of the disposal site to meet the performance objectives or may preclude defensible modeling and prediction of long-term impacts.

   This requirement also relates to the stability of the disposal site. The natural processes affecting the disposal site should be occurring at a consistent and definable rate. In addition, those processes should not occur at a frequency, rate, or extent which can significantly change the stability of the site or the ability of the disposal site to isolate low-level radioactive wastes for the duration of the radiological hazard (approximately 500 years). Any changes should not invalidate the results of any modeling and prediction of long-term impacts.

10. The disposal site must not be located where nearby facilities or activities could adversely impact the ability of the site to meet the performance objectives or significantly mask the environmental monitoring program.

    This requirement is included so that the evaluation of any proposed disposal site will include not only the impacts of that disposal site on its surroundings but also the impacts of the surroundings on the disposal site. For example, damming of downstream rivers, blasting associated with quarry activities, subsidence and/or earth fissuring caused by groundwater withdrawals, and groundwater rises associated with heavy irrigation may adversely affect the ability of the site to meet the performance objectives. Nearby sources of airborne radionuclides, drift from cooling towers at nearby electrical generating stations or other industries, adjacent hazardous waste disposal facilities, and injection of water and/or liquid wastes upgradient from the disposal site may adversely affect the ability to monitor the performance of the disposal site. In cases of co-located facilities, the monitoring programs for the facilities should be able to identify the source and differentiate between the releases of the separate facilities. In

addition, the monitoring programs should provide adequate data to identify mitigative measures, if needed, for the separate facilities.

It is instructive at this point to examine how the NRC expects its siting criteria to be utilized in the site selection process. This guidance is also discussed in NUREG-0902 and briefly described here.

The first step in this process will consist typically of defining the region of interest, such as the area within the geographic boundaries of an individual state or regional compact. The second step will consist of screening the region of interest to identify potential sites. In the third step, the potential sites will be screened against a common set of criteria, including the minimum technical requirements in 10 CRF Part 61 and the environmental standards in 10 CRF Part 51 (selection currently under revision to conform to NEPA requirements). The third step is envisioned as a coarse screening process which will identify a slate of candidate sites for more detailed review.

The fourth step will consist typically of a detailed review of the slate of candidates identified through a coarse screening. The first four steps will rely primarily on available reconnaissance level information. The primary differences between the steps will be the level of detail of the review and the inclusion of additional items to be evaluated in each step. For example, the fourth step may include items such as conceptual designs, preliminary cost estimates, release scenarios, and pathway studies which were not included in the previous steps. The fourth step will conclude with the selection of a preferred site from among the candidate sites.

In some cases, limited investigations of site characteristics at some or all of the candidate sites may be needed during the fourth step to evaluate these additional items and to adequately distinguish between the candidate sites such that a preferred site can be identified. However, the major portion of the site characterization studies will be performed at the preferred site after selection from among the candidate sites. Only if the detailed site characterization studies identify unanticipated adverse conditions at the preferred site would detailed investigations be performed at more than one site.

The NEPA regulation requires a comparison of alternatives to the proposed action. In meeting this regulation, there should be comparison between the preferred site and two or three viable alternative sites selected from among the candidate sites. Viable alternative sites can be defined as sites that, although not selected as the preferred site, would meet the minimum technical requirements and would reasonably be expected to meet the performance objectives. To the extent that the diversity of candidate sites will permit, the comparison between the preferred and alternative sites should include consideration of different geologic media, different conceptual designs afforded by the alternative sites, different environmental impacts associated with each site in the comparison, and projected cost differences.

One of the reasons for covering this siting process is to note the NRC's desire to only consider site characteristics in the fourth step. Site characteristics are also described in NUREG-0902 and fall into the following categories

- Meteorology
- Surface Water
- Groundwater
- Geology
- Geomechanics and Soils
- Air Quality
- Ecology
- Land Use and Cultural Resources
- Socioeconomics.

Information needs for each of these categories are described in Table 4. These items are covered in detail in NUREG/CR-2700. The reader will note the similarity between items covered above and what many people confused for siting criteria. These are more akin to the "factors" described in the Confusion Section of this report. As a result of future public input, it may be determined that some of the itmes in Table 4 should be restated as criteria. This possibility should be discussed further. The NRC feels there is a need to evaluate these characteristics (factors) in the fourth siting step to develop the information needed for:

- Demonstration that the performance objectives and the minimum technical requirements on site stability will be met

- Evaluation of the ability of the site characteristics to contribute to isolation of the low-level radioactive wastes

- Design of the near-surface disposal facility
- Identification of interactions between the site characteristics and the low-level radioactive waste and waste containers
- Establishment of data collection points and a baseline of data for some portions of the site monitoring program
- Identification of potential environmental impacts resulting from construction, operation, and closure of the near-surface disposal facility.

It must determined how much of this information may be available in a form to allow it to be utilized in the application of the siting criteria themselves. Table 5 is taken from NUREG/CR-3038 and provides a listing of parameter testing requirements for the site characteristic phase. It supplementss to some extent the material in Table 4.

The above discussion was provided to illustrate the separation envisioned by the NRC between criteria and factors. One can use the information in Table 4 to compare to the lists derived by other states and the concerns of the people involved in the WESTON public input process.

DEVELOPMENT OF ADDITIONAL CRITERIA

From the description of the NRC criteria in the section above, the reader can gain a sense of what constitutes a criterion in the true sense of the word. Through further public input, the wording of these NRC criteria can be altered somewhat to become both easier to understand and more specific to the chosen design and conditions as they might exist in Massachusetts. While the NRC criteria may offer a start in the search for a basis upon which to screen potential regions, there are certainly other concerns that may need to be addressed. Unfortunately, as stated above, the NRC is not authorized to consider any additional criteria for non-Agreement States. This section will address these additional concerns should a limited Agreement status be sought by the Governor for Massachusetts.

Siting is a very important issue with respect to potential LLRW facility development here in Massachusetts. Section 4.b.ii. of Chapter 503 of the Massachusetts statutes reads as follows:

> "No facility for the disposal or storage of low-level radioactive wastes shall be constructed or operated within the Commonwealth unless...the General Court has found, and has certified by resolution duly adopted by a majority vote of the members of each House...that the site of the proposed waste facility is superior to all other available sites from the combined standpoints of overall cost, reliability, safety, environmental impact, land use planning, and avoiding social and environmental dislocation."

The need for additional criteria to meet these concerns as expressed in State law is apparent. WESTON has examined the primary literature (Table 1) and the "Group Memories" of the public input sessions (Appendix II) in an effort to identify additional concerns not reflected in the NRC criteria. This section does not attempt to resolve which of the items listed in Tables 4 and 5 should be developed into criteria. Public consideration of the NRC rationale (NUREG-0902 and NUREG/CR-2700) for not including extra criteria for these items is needed followed by small group discussion of this issue.

Perhaps the most exhaustive listing of siting criteria ever attempted for LLRW is the Wisconsin Report. Table 6 provides a listing of the "criteria" discussed in that report. The reader will note the similarity of this material with the NRC information in Tables 4 and 5. Wisconsin even mixes design and operational considerations into its "criteria" (e.g., waste characteristics, burial techniques, retrievability, etc.). Further public discussion is needed on this listing as with the NRC characteristics (factors).

The information presented in Table 7 is from a paper in NUREG/CP-0028. It provides an interesting summary of a variety of federal government siting criteria studies specific to the LLRW issue over a 20 year period. Many of these criteria are included in the NRC listing. Some reflect design and operation considerations. However, several additional concerns are indicated and were reflected in the public input sessions even though this information was not specifically applied to the groups. The legend attempts to show how independently derived criteria have much consensus built in.

The information presented in Table 8 is from a New England Regional Commission report. Although this was derived for hazardous waste management facility sites, it is similar in most respects with the other Tables and the NRC listing. It is included here because it was derived with a more local flavor to this region.

With this brief introduction there are three areas which deserve separate criteria. They include site size, location and transportation. Each will be discussed briefly below. WESTON decided not to give special consideration to climatic conditions, critical ecological areas, socioeconomic concerns and biology issues since they are specifically covered in NUREG-0902 and are mentioned in Table 4. In no manner does this distinction prevent them from further considerations as developable into criteria.

1. The site shall be of sufficient area (and depth) to accommodate the projected volume of waste and a three-dimensional buffer zone of sufficient size to allow unrestricted human use beyond its boundary. The buffer zone shall provide accessibility for monitoring and the site should be situated in a manner as to allow passive monitoring whenever possible.

2. To the extent consistent with other criteria, the site shall be selected with consideration given to the location of waste generation, access to all-weather highways, access to utilities, and accessibility of all required emergency services.

3. Special considerations provided by the other siting criteria should be applied (perhaps in a more limited fashion) to the transportation corridors used to transport wastes to the site. The extent to which design and operations considerations can be utilized to address transportation concerns will determine the extent to which the criteria apply.

Some rewording of these criteria may be needed just as the case may be with the NRC criteria. Discussion of the factors associated with these additional criteria would also be useful.

CONCLUSIONS

WESTON feels that this document, in its present form, portrays the issues and substance of what is required to derive siting criteria for Massachusetts. Although separation of criteria and factors is technically possible as described in this report, it may not be desirable from a public point of view. Some other distinction may be possible and some of the factors may be developed into criteria.

In order to proceed to the final selection of siting criteria, it is imperative that the design and operations considerations be narrowed significantly. This can be done with the materials currently being prepared for the EOEA as discussed in the Introduction. With this information in a more manageable form, further discussion of the relevant criteria can proceed.

WESTON chose to develop this document only after public input in small group facilitated sessions. Many of the items derived from this effort fall under the area of factors which were addressed by the NRC (see Table 4 and related discussion) outside its ten criteria. The public was not fully aware of the NRC literature and thought process. It would be interesting to bring together the same groups again with this report and the primary literature to see how their views might change. Perhaps the EOEA or a MHRI contractor could accomplish this task in order to derive an acceptable listing of final siting criteria.

The public did not wish to discuss their concerns for design and operations issues separately from the siting criteria issues. The interrelationship is a very strong one in the public's mind and cannot be easily separated in a technical manner such as the NRC chose to do in its literature. A separate concern here was the topic of shallow land burial. This issue and the local resentment of this design option was discussed in the Introduction. It is quite apparent that separate small group facilitated sessions on the design options are required. The NRC also needs to address the special siting criteria need for alternative facilities (since all their present criteria are specific to "near-surface" or shallow land burial options). The NRC input could be considered by the public in future deliberations on the siting criteria.

More work is needed. Siting is an extended process. This report has attempted to take the first step. Only after obtaining facilitated public input was this step taken. Suggestions have been made above with respect to additional steps which are required. Some of the contractual restrictions (see Introduction) that were placed on this step need to be resolved so that the process can continue. As more and more information is generated and reviewed by the public, it can be refined and built upon so that progress can be made should the Governor decide that the siting process should be formally intiated here in Massachusetts.

TABLE 1.

PRIMARY REFERENCES FOR WESTON SITING CRITERIA

TABLE 1. Primary References for Weston Siting Criteria

A Process for Locating Shallow Land Burial Sites for Low-Level Radioactive Waste, DOE-EG&G Publication, LLW-16T, March 1983.

Study of Siting Criteria for Development of a Low-Level Radioactive Waste Facility, Wisconsin Geological and Natural History Survey, University of Wisconsin, November 1981.

Phase I Summary, Low-Level Radioactive Waste Disposal Siting Study, Dames and Moore, EIS-NUREG 0945, Volume 3, May 1983.

The Siting Book: A Guidebook for Siting Hazardous Waste Facilities in Massachusetts (Draft), Urban Systems Research and Engineering for DEM, April 1983.

A Handbook for Low-Level Radioactive Waste Disposal Facilities, EPRI Report NP-2488LD (Interim), Rogers and Associates, September 1982.

Site Suitability Selection and Characterization, Branch Technical Position - Low-Level Waste Licensing Branch, NUREG 0902, NRC, April 1982.

Proceedings of the Symposium on Low-Level Waste Disposal - Site Suitability Requirements, NUREG/CP 0028, CONF-811218, Volume 1, December 1981.

Evaluation of Alternative Methods for the Disposal of Low-Level Radioactive Wastes, NUREG/CR 0680, FBDU-209-03, July 1979.

Draft EIS on 10 CFR, Part 61 - Licensing Requirements for Land Disposal of Radioactive Waste, NUREG 0782, September 1981.

Criteria for Evaluating Sites for Hazardous Waste Management - A Handbook on Siting Acceptable Hazardous Waste Facilities in New England, New England Regional Commission, November 1980.

10 CFR Part 61 Regulations of NRC, Federal Register, 47(248) 57446ff, December 27, 1982.

Phase II Regulations, Commonwealth of Massachusetts, Department of Environmental Quality Engineering.

Managing Low-Level Radioactive Waste in Massachusetts, Massachusetts Department of Public Health, Radiation Control Program, December 1983.

Low-Level Radioactive Waste Management in Massachusetts, Massachusetts Advisory Council on Radiation Protection, November 1980.

Low-Level Radioactive Waste Disposal Options for Maine, Maine Low-Level Radioactive Waste Siting Commission, February 1984.

Low-Level Radioactive Waste Disposal Siting Study, Texas Low-Level Radioactive Waste Disposal Authority, May 1983.

Low-Level Radioactive Waste Overview, Institute for Research on Land and Water Resources, Pennsylvania State University, January 1984.

Low-Level Radioactive Waste Management for Vermont: An Analysis of Alternatives, Vermont Agency of Human Services, November 1983.

"Siting a Near-Surface Disposal Facility for Low-Level Radioactive Wastes", by D. Siefken and E. Hawkins, Proceedings of the 1983 National ASCE Conference on Environmental Engineering, Boulder, Colorado, July 6-8, 1983.

"Parameters for Characterizing Sites for Disposal of Low-Level Radioactive Waste", by USAE Waterways Experiment Station, NUREG/CR-2700.

"Tests for Evaluating Sites for Disposal of Low-Level Radioactive Wastes", USAE Waterways Experiment Station, NUREG/CR 3038.

TABLE 2.

NRC PERFORMANCE OBJECTIVES

TABLE 2. NRC Performance Objectives

61.41 - Protection of the general population from releases of radioactivity.

Concentrations of radioactive material which may be released to the general environment in groundwater, surface water, air, soil, plants, or animals must not result in an annual dose exceeding an equivalent of 25 millirems to any other organ of any member of the public. Reasonable effort should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable.

61.42 - Protection of individuals from inadvertent intrusion

Design, operation, and closure of the land disposal facility must ensure protection of any individual inadvertently intruding into the disposal site and occupying the site or contacting the waste at any time after active institutional controls over the disposal site are removed.

61.43 - Protection of individuals during operations

Operations at the land disposal facility must be conducted in compliance with the standards for radiation protection set out in Part 20 of this chapter, except for releases of radioactivity in effluents from the land disposal facility, which shall be governed by 61.41 of this part. Every reasonable effort shall be made to maintain radiation exposures as low as is reasonably achievable.

61.44 - Stability of the disposal site after closure

The disposal facility must be sited, designed, used, operated, and closed to achieve long-term stability of the disposal site and to eliminate to the extent practicable the need for ongoing active maintenance of the disposal site following closure so that only surveillance, monitoring, or minor custodial care are required.

TABLE 3.

KEY ASPECTS OF SITE SUITABILITY AIMED AT MEETING THE PERFORMANCE OBJECTIVES

TABLE 3. Key Aspects of Site Suitability Aimed At Meeting the Performance Objectives (NUREG/CP 0028)

1. Eliminate, to the extent practicable, the contact of water with waste during operations and after closure to reduce the potential for migration.

2. Assure long-term stability of the site and facility to eliminate the need for constant care and maintenance over the long-term with attendant uncertain high costs and long-term commitment of social resources.

3. Improve confidence in the predictability of the long-term performance capability of the facility.

4. Site facilities in locations where there is little likelihood of future human activities that could result in human intrusion.

TABLE 4.

SUMMARY OF MAJOR INFORMATION NEEDS FOR
NRC SITE CHARACTERIZATION

TABLE 4. Summary of Major Information Needs for NRC Site Characterization (NUREG/CR 2700)

Discipline	Item	
Meteorology	Wind speed and direction	Precipitation[a,b]
	Air temperature	Dew point
	Barometric pressure	Frost depth and dates[b]
	Severe storm data[b]	
Surface Water	Stream flow rate	Channel cross section
	Precipitation drainage area	100-year flood[b]
	Surface gradients	Surface water uses[b]
	Infiltration	Surface retention
	Evapotranspiration	Water quality
	Surface runoff	Erosion rates[a,b]
	Channel slope	Channel roughness
Groundwater	Depth to water table[a,b]	Hydraulic conductivity
	Aquifer location and flow[a,b]	Hydraulic gradients
	Aquifer velocity[a,b]	Transmissivity coefficient
	Aquifer surface outlets[a,b]	Retardation coefficient
	Dispersion coefficient	Groundwater chemistry
	Groundwater uses[a]	Groundwater quality
Geology	Stratigraphy[b]	Faults, fractures, etc.[a,b]
	Topographic map[b]	Geophysical measurements
Geomechanics & Soils	Atterberg limits	Coefficient of consolidation
	Proctor tests	Organic content
	Minerology	Particle size distribution
	Water content	Penetration resistance
	Bulk density	Angle of internal friction
	Permeability[a,b]	pH
	Buffer capacity	Redox potential
Air quality	Particulate loading	Radioactive particulate concentrations
	Particulate size distribution	Radioactive gas concentrations
Ecology	Flora inventory	Aquatic species inventory
	Fauna inventory	Potential for endangered species[b]
Land Use and Cultural Resources	Land use pattern	Cultural resources
	Current Zoning	Population distribution[b]
Socioeconomics	Human demography	Revenue base
	Political structure	Utilities
	Social structure	Services
	Labor force	Roads

a Key data useful for screening nuclide migration analysts.
b Key data useful for preliminary screening.

TABLE 5.

PARAMETERS AND PARAMETER GROUPS FOR
CHARACTERIZING LLW SITES

TABLE 5. Parameters and Parameter Groups for Characterizing LLW Sites

Stratigraphy
Lithology and soils
Structure
Geomorphology
Ground water system and boundaries
Surface water system and boundaries
Recharge and discharge areas
Visual description
Soil classification
Rock classification
Material zone boundaries
Water zone boundaries
Immediate site boundary
Extended site boundary
Color (material color)
Grain-size distribution or parameter (grain-size distribution)
Material densities
Water content
Soil water pH and acidity (soil pH and acidity)
Electrical conductivity or resistivity (electrical resistivity)
Penetration parameter
Material variability parameter
Hydraulic conductivities
Permeability function
Transmissivity
Storativity
Anisotropy
Porosities and void ratio
Hydraulic potentials and pressures
Seepage velocity
Apparent velocity
Flow direction
Dispersion
Pore water age
Suction pressures
Suction pressure function
Water-holding parameters
Infiltration capacity
Evapotranspiration
Precipitation
Runoff coefficients (runoff)
Air temperature
Air pressure
Wind speeds and directions
Partition coefficients
Mineralogy and clay mineralogy
Ion exchange capacities
Oxidation-reduction potential
Natural gamma and spectra (material radioactivity)
Soil solubles
Soil organics
Gaseous constituents
Ground water chemistry
Surface water chemistry
Atterberg limits
Specific gravity
Seismic velocity

TABLE 5 - Parameters and Parameter Groups for Characterizing LLW Sites
Page 2

Collapse susceptibility

Shrinking-swelling parameter

Strength

Consolidation relation

Compaction relation

Rebound index

Heaving susceptibility (frost heaving)

Erodibility parameters (erodibility)

Monument and point positions

Burial unit boundaries

Material temperature

TABLE 6.

WISCONSIN SITING CRITERIA

TABLE 6

WISCONSIN SITING CRITERIA FOR A
LOW-LEVEL RADIOACTIVE WASTE FACILITY*

NATURAL SITE CONSIDERATIONS

HOST MATERIAL

- Thickness
- Size
- Shape
- Geochemistry
- Porosity
- Permeability
- Corrosivity
- Mineral Surface Area
- Rock and Soil Mechanics

GEOLOGY

- Geologic Investigation of the Site
- Geologic Investigation of the Region
- Mineralogy
- Clay Content
- Grain Size
- Sorption
- Ion Exchange
- Salinity
- Solubility
- Subsidence
- Dissolution Voids
- Caverns and Karst
- Fractures and Joints
- Faulting
- Folding

*Study of Siting Criteria for Development of a Low-Level Radioactive Waste Facility, Stephanie A. Brouwer & Joe C. Yelderman, Jr., Wisconsin Geological and Natural History Survey, Special Report No. 7, Madison, Wisconsin, November 1981

Table 6
Wisconsin Siting Criteria for A
Low-Level Radioactive Waste Facility

Structural Stability
Excavation Characteristics
Landslides
Creep

GEOPHYSICS

Seismicity (Earthquakes, Volcanoes)
Tectonics

SOILS

Permeability
Infiltration

TOPOGRAPHY

CLIMATE

Precipitation
Evapotranspiration
Temperature
Wind (Direction, Velocity)
Trends
Cycles
Extremes

HYDROLOGY

Regional Hydrology
Site Hydrology
Surface Hydrology
Subsurface Hydrology

- Depth to Water Table
- Seasonal Variations in Water Table
- Importance or Significance of Aquifer

Table 6
Wisconsin Siting Criteria for A
Low-Level Radioactive Waste Facility

- Size of Aquifer
- Transmissivity
- Diffusion Coefficient
- Storage Coefficient
- Hydraulic Conductivity and Permeability
- Dispersion and Dispersivity Coefficients
- Distribution Coefficients
- Aquifer Boundary Conditions
- Recharge Areas
- Discharge Areas
- Location of Aquifers
- Groundwater Flow or Gradient

    direction of flow
    rate of flow
    volume of flow
    ability to control flow
    predictions of future flow conditions

- Chemistry of the Groundwater

FLOODS

Erosion Due to Floods

Surface Water Contamination from Floods

Ponding and Infiltration from Floods

Groundwater Changes from Floods

EROSION

Types

- Water Erosion
- Wind Erosion
- Mass Wasting
- Glacial Erosion
- Catastrophic Erosion

Rates of Erosion

Depths of Erosion

WEATHERING

Table 6
Wisconsin Siting Criteria for A
Low-Level Radioactive Waste Facility

SITE IMPACTS TO THE ENVIRONMENT

LAND

WATER

NOISE

AIR

ESTHETIC, CULTURAL, NATURAL, AGRIGULTURAL, HISTORICAL AND RECREATIONAL VALUES

BIOLOGY

- Flood Chains
- Plant Uptake
- Wetlands

EXTERNAL HAZARDS

HUMAN INTRUSION

ANIMAL INTRUSION

PLANT INTRUSION

METEORITE IMPACT

GLACIATION

PROCESS CONSIDERATIONS

RISK ANALYSIS

MONITORING

MODELING

Table 6
Wisconsin Siting Criteria for A
Low-Level Radioactive Waste Facility

COMPLEXITY

HUMAN CONSIDERATIONS

HUMAN HEALTH AND SAFETY

Environmental Monitoring

Long-term Care

DEMOGRAPHIC CRITERIA

Population Size, Density, and Distribution

Anticipated Demographic Patterns

Immigrants and their Effects on Local Population

SOCIAL CRITERIA

Public Education and Opinion

Public Involvement and Acceptance

Risk Assessment and Perception

Ethical Considerations

Impact Mitigation

Incentives and Benefits

Compensation and Liabilities

Change in Local Community

LEGAL-INSTITUTIONAL CRITERIA

Institutional Control

Federal Authority

State Authority

Local Authority

- Zoning and Land Use Authority
- Emergency Preparedness Planning

Land Ownership

Legislation

Table 6
Wisconsin Siting Criteria for A
Low Level Radioactive Waste Facility

Regulations

Public Policy Formation

Political Issues and Regionalization

Decision-making Process

Cost to Plan, Construct, Operate, Maintain and Decommission a Site

Cost-Benefit Analysis

Labor Availability

Perpetual Care Funds

Socioeconomic Issues

GEOGRAPHIC AND LAND-USE CRITERIA

Future Land Use

- Resource Potential
- Irrigation
- Buffer Zone Availability
- Distance from Restricted Land Use

Present Land Use

- Location
- Acccessibility
- Population
- Distance to Nearest Water Use
- Availability of Construction Material

Past Land Use

Dams

TRANSPORTATION

Table 6
Wisconsin Siting Criteria for A
Low Level Radioactive Waste Facility

WASTE CONSIDERATIONS

WASTE CHARACTERISTICS

- Persistence
- Concentration
- Toxicity
- Waste Form or Packaging
- Volume
- Mobility in Water
- Waste Solubility
- Precipitation of Waste
- Reactivity of the Waste

BURIAL TECHNIQUES

- Depth of Burial
- Methods of Excavation
- Backfill, Cover or Overburden Material
- Method of Filling the Hole or Plugging
- Sealing
- Decommissioning

RETRIEVABILITY

TABLE 7.

COMPARISON OF LLW SITE SELECTION CRITERIA
FROM DIFFERENT SOURCES

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TABLE 7. Comparison of LLW Site Selection Criteria from Different Sources, 1960 - 1981 (NUREG/CP 0028)

NO.	CRITERION	ORIGIN	IS CRITERION OR FACTOR IN CRITERIA SET: EPA SSC 1974	NRC P.61 1981	USGS 1974	IAEA 1981	EPA BWC 1978	FED REG 1978	AEC 1960
1.	NATURAL CHARACTERISTICS OF SITE SHOULD PREVENT MOVEMENT OF CONTAMINANTS TO PLACES WHICH ADVERSELY AFFECT MAN.	EPA SSC	●	●	●	●	●	●	●
2.	SITE SHOULD HAVE SIMPLE HYDROGEOLOGIC SETTING & SYSTEM.	"	●	●	●	●	—	●	—
3.	SITE SHOULD BE DEVOID OF SURFACE WATERS & FLOOD PLAINS.	"	●	●	●	●	—	●	●
4.	BURIAL ZONE SHOULD NOT BE IN FRACTURED ROCK & SHOULD BE SEPARATED FROM FRACTURED BEDROCK (IMPLIES INTERGRANULAR PERMEABILITY).	"	●	⊙	●	●	—	●	△
5.	MOVEMENT OF CONTAMINANT IN SHALLOW ZONE SHOULD BE SLOW (DECADES OF DELAY).	"	●	⊙	●	●	—	⊙	●
6.	DISPOSAL ZONE SHOULD BE SEVERAL METERS ABOVE WATER TABLE.	"	⊙	⊙	⊙	⊙	—	⊙	⊙
	OR								
7.	DISPOSAL ZONE MAY BE BELOW WATER TABLE IF HYDROGEOLOGIC CONDITIONS ARE FAVORABLE.	"	●	●	●	●	—	△(1)	●
8.	HYDROGEOLOGIC SYSTEM SHOULD BE PREDICTABLE (ABLE TO MODEL).	"	●	●	●	●	●	●	—
9.	SITE CAN BE MONITORED.	"	●	●	●	●	⊙	●	—
10.	STABLE GEOMORPHOLOGY AND LOW EROSION RATES AND POTENTIAL.	"	●	●	●	●	—	●	●
11.	SUBSURFACE FLOW SYSTEM MUST BE KNOWN (3-DIMENSIONAL HEAD DISTRIBUTION, ETC.).	"	●	⊙	●	●	⊙	●	—
12.	SUBSURFACE GROUND-WATER FLOW NOT TO UNDESIRABLE AREAS (PUBLIC WATER SUPPLIES, FRACTURED ROCK).	"	●	●	●	●	●	●	●
13.	CONTAMINANTS SHOULD BE RETAINED WITHIN SITE 100s OF YEARS.	"	●	●	●	●	—	●	—
14.	LARGE FLUCTUATIONS IN WATER TABLE UNLIKELY.	"	●	●	●	●	—	△(1)	—
15.	FLOW PATTERNS OF REGIONAL HYDROGEOLOGIC SYSTEM SHOULD BE KNOWN OR DETERMINED.	"	●	●	●	●	⊙	●	—
16.	PREDICTIONS OF SYSTEM PERFORMANCE SHOULD INCLUDE MATHEMATICAL SIMULATION MODELING.	"	●	●	●	●	●	●	—
17.	POSSIBILITY OF TAKING REMEDIAL/MITIGATING ACTION DESIRABLE.	"	●	⊙	●	●	—	●	—
18.	CONTACT BETWEEN WASTE AND WATER SHOULD BE MINIMIZED.	"	●	●	●	●	—	●	—
19.	BUFFER ZONE SHOULD BE 20-50% GREATER THAN EXPECTED MOVEMENT OF CONTAMINANT (FOR SAFETY AND SITE EXPANSION).	"	●	△	●	●	—	●	●
20.	SITE SHOULD NOT BE IN 100-YEAR FLOOD PLAIN & NOT SUBJECT TO FLOODING.	NRC P61	⊙	●	⊙	●	—	●	—
21.	GROUNDWATER DISCHARGING TO SURFACE OF SITE MUST NOT ORIGINATE FROM DISPOSAL FORMATION	"	—	●	—	—	—	—	—
22.	AREAS WITH DISTRUCTIVE TECTONIC PROCESSES SHOULD BE AVOIDED.	"	⊙	●	⊙	●	—	●	—
23.	RETENTION CAPACITY OF SITE FOR SPECIFIC RADIONUCLIDES SHOULD BE DETERMINED.	IAEA 1981	⊙	⊙	⊙	●	—	⊙	—
24.	SELECTION OF SITE IS SUBJECT TO ACCEPTANCE THROUGH PROCESS THAT REVIEWS POTENTIAL ENVIRONMENTAL IMPACT.	"	●	●	●	●	●	●	—[8]
25.	USE OF ENGINEERING AND WASTE BARRIERS TO COMPENSATE FOR LACK OF SOME NATURAL SITE BARRIERS CAN BE CONSIDERED.	"	●	●	●	●	●	●	●
26.	NO RELIANCE ON ENGINEERING/INSTITUTIONAL CONTROLS REQUIRING MAINTENANCE BY MAN FOR MORE THAN 100 YEARS.	BWC EPA	—	●	—	—	●	—	—

LEGEND

● YES, INCLUDED
⊙ YES, IMPLIED
— SILENT ON MATTER
△ AREA OF SIGNIFICANT CHANGE OR POTENTIAL DISAGREEMENT

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TABLE 7. Comparison of LLW Site Selection Criteria from Different Sources, 1960 - 1980 - Page 2

27. HYDROGEOLOGIC CONDITIONS SHOULD ENHANCE ISOLATION OF WASTES OVER TIME.	EPA B/C	—	—	—	—	●	—	—
28. HYDROGEOLOGIC, ECOLOGIC, LAND-USE AND SOCIO-ECONOMIC ELEMENTS OF SITE SHOULD BE DESCRIBED.	REG9 1978	⊙	⊙	⊙	●	⊙	●	—
29. NO WATER-USE POINTS SHOULD BE CLOSE BY.	AEC 1960	⊙	⊙	⊙	⊙	—	⊙	●
30. PREDOMINANTLY SHALEY BEDROCK IS DESIRABLE, "THE THICKER, THE BETTER."	"	△	△	△	△	—	△	●
31. CLAY OR CLAY-RICH OVERBURDEN AT LEAST 20 FEET THICK DESIRABLE.	"	△(3)	△(3)	△(3)	△(3)	—	△(3)	●
32. GROUNDWATER AT SITE SHOULD BE HYDRAULICALLY ISOLATED FROM GROUNDWATER OF SURROUNDING TERRANE.	"	—	—	—	—	—	—	●
33. MILD CLIMATE AND MODERATE RAINFALL ARE DESIRABLE.	"	—	—	—	—	—	—	●
ECOLOGICAL/BIOLOGICAL CRITERIA AND FACTORS								
34. TOTAL ECOLOGICAL IMPACT OF ESTABLISHING SITE SHOULD BE PREDICTABLE.	REG9 1978	⊙	⊙	⊙	●	—	●	—
35. POTENTIAL EFFECTS ON EACH ECOLOGICAL ELEMENT/ FACTOR CAUSED BY DISPOSAL ACTIVITIES, DIS-PLACEMENT BY SITE OR PROTECTION BY SITE SHOULD BE ASSESSED.	"	⊙	⊙	⊙	●	—	●	—
36. BIOLOGICAL COMMUNITIES, ECOLOGICAL RELATION SHIPS & CRITICAL POPULATION GROUPS SHOULD BE ASSESSED.	"	⊙	⊙	⊙	●	—	●	—
37. RELATIVE SIGNIFICANCE OF ABOVE CHANGES SHOULD BE EVALUATED.	"	⊙	⊙	⊙	●	—	●	—
38. FACTORS CRITICAL TO CONTAINMENT AND TRANSLOCATION OF WASTE SHOULD BE EVALUATED (RUDERAL OR DEEP-ROOTED PLANTS, BURROWING ANIMALS, ETC.)	"	⊙	⊙	⊙	●	—	●	—
LAND USE AND STATUS CRITERIA AND FACTORS								
39. WATER RESOURCES MANAGEMENT.	"	—	—	—	●	—	●	●
40. MINING CLAIMS AND OPERATIONS.	"	—	—	—	●	—	●	—
41. PERMITS, EASEMENTS AND WITHDRAWALS.	"	—	—	—	●	—	●	—
42. OUTDOOR RECREATION.	"	—	—	—	●	—	●	—
43. ESPECIALLY DESIGNATED AND SPECIAL INTEREST AREAS.	"	—	—	—	●	—	●	—
44. STATE AND LOCAL ZONING AND LAND USE PLANS.	"	—	—	—	●	—	●	—
45. AGRICULTURAL USE AND ACTIVITIES.	"	—	—	—	●	—	●	—
SOCIO-ECONOMIC CRITERIA AND FACTORS								
46. PROXIMITY OF SITE TO WASTE GENERATORS.	"	—	—	—	●	—	●	—
47. ADEQUACY OF TRANSPORT SYSTEMS AND NETWORKS.	"	—	—	—	●	—	●	●
48. EFFECTS OF RESOURCES FORECLOSE BY COMMITMENT OF LAND TO WASTE DISPOSAL SHOULD BE CONSIDERED (ECONOMIC LOSS AND INTRUSION.)	"	—	●	—	●	●	●	—
49. LOW POPULATION DENSITY IS DESIRABLE.	"	●	●	●	●	—	●	●
50. LAND SHOULD BE FEDERAL OR STATE OWNED.	"	—	●	—	●	—	●	●
51. IMPACT ON COMMUNITY AND EMPLOYMENT.	"	—	●	—	●	●	●	—
52. POLITICAL AND INSTITUTIONAL CONSTRAINTS (INCLUDING PUBLIC ACCEPTANCE.)	"	—	—	—	●	—	●	—
53. LAND VALUES SHOULD BE LOW AND SITE SHOULD NOT DEPRESS VALUES OF PERIPHERAL PRIVATE LAND.	AEC 1960	—	⊙	—	⊙	—	—	●

(1) Not necessary because large areas with deep water table are available .
(2) Requirement for EIS did not exist.
(3) Not unless extensive site and trench engineering and/or waste conditioning is done.

TABLE 8.

NEW ENGLAND REGIONAL COMMISSION SITING CRITERIA FOR HAZARDOUS WASTE FACILITIES

TABLE 8. New England Regional Commission Siting Criteria for Hazardous Waste Facilities (NERCOM Report)

Area	Criteria
Surface and Groundwater	• Contaminant flow period to water table • Contaminant movement with groundwater • Predictability of contaminant movement • Potential effect on surface water • Potential effect on aquifers • Potential effect on public water supplies • Possibility of site flooding • Potential human exposure to treated wastewater
Air	• Nature and predictability of air pollutant movement • Potential human exposure to air pollutants
Transportation System	• Safety of transportation route • Distance between sensitive sites and transportation route • Potential for noise impacts
Land Use	• Potential for impact on environmentally significant lands • Proximity to residential areas or sensitive sites • Compatibility with existing land uses and land use plans
Economic	• Potential effect on property values • Impact on existing or future economic activity
Other	• Potential for earthquake activity

APPENDIX I

RFW FACILITATED MEETINGS MAILING LIST

APPENDIX I

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APPENDIX II

"GROUP MEMORIES"

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GROUP MEMORY - PITTSFIELD MEETING
MARCH 19, 1984

The group consisted of the following individuals:

George S. Wislocki, Massachusetts Association of Conservation Commissions

Joseph Levine, Berkshire Medical Center

Edward Tarnuzzer, Yankee Atomic Electric

Donald Grose, Citizen, Chesterfield, MA

Robert Spencer, Berkshire County Regional Planning Commission

Denise Cormier, Citizen, Chesterfield, MA

Robert B. Pojasek, Roy F. Weston, Inc.

Merle Lefkoff, Facilitator

It was decided by the group to use the Nuclear Regulatory Commission (NRC) criteria as a basis for initial discussion (Table 1). The following pages are the verbatim recording of the facilitated session.

WESTON

GROUP MEMORY - PITTSFIELD MEETING
March 19, 1984

AGENDA

1. Ten NRC Criteria (20 minutes)

2. Other Criteria (above-ground storage)

3. Other Business

WESTON

Group Memory - Pittsfield Meeting
March 19, 1984

NRC CRITERIA

1. What is a site characterization?
   - Climate should be analyzed and accurately monitored 12 months a year.
   - Site should be homogeneous.
   - Site should be "monolithic".
   - Site can be accurately monitored.
   - Site can be accurately modeled.
   - "You know what's going on."
   - No surprises. Predictable.

10. Deals with area around the site, but can't have structure or activity which would interfere with the above.

2. What does "future developments" mean?
   - Population growth.
   - Industrial development.
   - Additional transport networks.
   - "Environs" around site are restricted from any future development.

   What about "performance objectives"?

   - NRC
     - Protect general public from radioactivity
     - Protect general public from getting on-site
     - Protect general public from workers
     - Stability of site after closing.
   - Size of site - buffer.
   - Amount of $ to manage site.

3. Add "or adjacent area".
   ...And if resources are exploited could change the character of the site, itself, e.g., groundwater, oil or minerals, gas, limestone, timber, uranium, lead (all present in Western Massachusetts).

Group Memory - Pittsfield Meeting
March 19, 1984

NRC CRITERIA (cont'd)

4. Old dams? (Below)

5. Does this include engineering methods? They may be suspect. Maybe should be modified to stress "natural run-off" solutions. Trade-offs apparent if upstream drainage is minimized - also ambiguous. We don't understand this one? What's its justification?

6. Why not strike second sentence? Okay.

7. Discharge = seep.
Groundwater from the site should not enter surface water. Does this criterion rule out Mass.? Does this imply you can have a g.w. discharge if it originates outside the site? This is questionable.

*Movement of groundwater is of great concern in Mass. and should be carefully addressed.

8. ----

9. What's "slumping"?

- DEF. OF "LOW-LEVEL"?

Highest class of low-level (Class "C") must be isolated for 500 years.

10. (cont.) - What about natural radioactivity near site interfering with monitoring?

WESTON

Group Memo - Pittsfield Meeting
March 19, 1984

OTHER CRITERIA

Above Ground Storage Design Criteria
(Not Siting Criteria)

1. Integrity of container (given temporary life of facility).

2. Careful inventory and separation.

*3. Must be able to retrieve what has been stored.

4. "Eternal vigilance" - problem of total dosage over time of workers.

5. Problem of technology because of N.E. weather.

Does above ground imply change of performance objectives?

What are major disadvantages of above ground?

- o more readioactivity pop. exposure
- o more monitoring requirements.
- o inadvertant intruder.

---

*Security - isolation becomes more important consideration.

*Areas where severe weather is likely should be avoided.

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GROUP MEMORY - AMHERST MEETING
MARCH 20, 1984

The group consisted of the following individuals:

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Ward Mott, Hydrogeologist, University of Massachusetts

Robert Biagi, Chairman, Board of Selectmen, Leverett, MA

Herb Bryan, Citizen, Amherst

John Sackrey, Citizen

Sara Walen, Hydrogeologist, Hadley

Fran Van Treese, Citizen, Amherst

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Robert B. Pojasek, Roy F. Weston, Inc.

Merle Lefkoff, Facilitator

The group was provided with a copy of the Nuclear Regulatory Commission (NRC) criteria (Table 1). However, a decision was made to proceed with their concerns of siting criteria and not to be bound solely to NRC criteria. The following pages are the verbatim recording of the facilitated session.

GROUP MEMORY - AMHERST MEETING
MARCH 20, 1984

Landfill can be safe (?).

- Psychological factors, so need "fail-safe" mechanisms:

1. No dense pop.
2. Groundwater not an aquifer
*3. Double liner
   a) sand lense - drain -

Vol. 15, #1 Groundwater

Nov.-Dec. '83 "Evaluation of Surface Impoundment in N. Mexico", Vol. 21, #6.

SITING

*1. Natural hydrolog. and geolog. conditions to assure safety. Suff. permeability and transmissivity. Must be able to retrieve leaks.

500 years is fine.

Many dump sites?

---

1. Where the profits are made (*run by the State).
2. Where the taxes are collected.
3. Where the greatest use is.
4. Need not be profitable
5. Local control over site and transportation routes

Group Memory - Amherst Meeting
March 20, 1984

Critical nature of economic necessity to state of generator.

Criteria of how salient the fight is to the people in the Pioneer Valley - of anywhere where populace might fight hard. (Polit., cost, safety criteria).

Siting criteria should be in plain English.

100% retrievability.

Waste should be carefully separated.

Sited in a pop. center (?). Argument is that it would then have to be perfectly safe.

Travel as little distance as possible. Transp. safety should be addressed regionally.

Transp. agent must be well-screened and responsible for accidents.

Site must have available full-time professional fire and police protection (emergency protection).

Establish public training for how to respond to a leakage. Training should be well coordinated and a serious effort. All Towns through which waste passes should have full-time professionals (fire and police). Transp. schedule should be noted well in advance.

**Transportation issues very important in rural areas - lack of resources for adequate staffing and response (e.g., snow removal). "How dangerous is this stuff? What does a spill really mean? Is clean-up harder on a dirt road than a paved road?

Site and surrounding area have a year-round escape ability.

Optimal climate conditions: low rainfall, tornadoes, snow, frost, pH, synergistic reactions.

Land cover - deciduous vs. evergreen.

Forest fires.

Group Memory - Amherst Meeting
March 20, 1984

Soil types - *use of SCS maps - characteristics.

Criteria for soil and water should go beyond existing data and maps. Not enough understanding. *Needs to be site-specific data.

Site not be taken by eminent domain (?). (Person should not be forced off their land.)

Site might be land already damaged (e.g., old dump site).

No one living within 40 miles of a site. (?)

Critical habitats (unique, species need it, etc.) should be excluded.

Not near air traffic lanes or airport(s).

Insurance for potentially affected publics be adequate. Site operator or transp. agent or generator be liable for damages.

NRC #6 - "sufficient". NOT SUFFICIENT! Any water table elev. or water table data be established using long-term hydrogeologic data - 100 years.

Mass. data be stressed in technical analysis of criteria. Technical analysts should be local if possible, but at least knowledgeable about local areas.

#6 AGAIN! "Diffusion" NO. Maybe "containment" instead. Water table should be at least 20 feet below the bottom of the facility.

Build into current siting process, an anticipation of the next site, by building data base, etc.

Criteria should include specified safety requirements for closing a site.

Size of the site should be appropriate to deal with the volume of waste it is supposed to handle (?).

Size of the site should be appropriate to deal with Mass. waste only (?).

Site should be able to be restored and/or retrieved to original environmental state, after decommissioning.

Site should be carefully monitored, including fish liver monitoring.

Group Memory - Amherst Meeting
March 20, 1984

Site should be impervious to intrusion from outside sources, like terrorists, animals, etc.

Site should be secure from changing the rules of the game later, e.g., "stuffing" with too much waste or new activities not originally intended.

Site should accommodate a facility which is large in surface area for purposes of ease of accessability to problems in facility.

Monit. stations should be distributed at appropriate intervals to better locate leakage and other problems.

Site and technology should be specific (appropriate) to type(s) of waste.

One criterion should be stressing the limited capabilities of the volume of waste to be stored so that waste reduction then becomes part of the planning process.

Site must be suitable based on existing natural environment without alteration, e.g., Corps altering drainage patterns.

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GROUP MEMORY - BOSTON MEETING
MARCH 21, 1984 - AFTERNOON SESSION

The group consisted of the following individuals:

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Merle Lefkoff, Facilitator

It was decided by the group not to use the Nuclear Regulatory Commission (NRC) criteria as a basis for initial discussion. Instead, the group defined criteria categories and brainstormed the criteria which would fit into each category. The following pages are the verbatim recording of the facilitated session.

GROUP MEMORY - BOSTON MEETING
MARCH 21, 1984 - AFTERNOON SESSION

NRC
General categories - look at NRC to compare.

---

1. Water

   a) Groundwater

   Shouldn't erode the cover.

   Drinking water should remain uncontaminated by any further radioactivity.

   Drainage from the site is worrisome.

   Criterion - prevention of intrusion of groundwater to site.

   Characterize flow patterns, chem., cyclic rise and fall.

   Safe drinking water stand should be applied

   Site location should be away from d.w. supplies or sole source acquifer. Relationship w. acquifer is necessary. Should be looking at extreme changes potentially assoc. with acquifer.

   Indirect contamination of other water (e.g., irrigation) should be avoided.

   NRC #6. The exception is problematic. One problem is lack of distinct. between natural and unatural radioactivity.

OTHER CATEG.

		Time
1.	Water	1. S.W. -10
2.	Intrusion	2. -5
3.	Climate	3. -10
4.	Geology	4. -15
5.	Land Use	5. -5
6.	Social Impacts	6. -5
7.	Natural Resources	7. -5
8.	Monitoring (Mask)	8. -10
9.	Aesthetics	9. -5
10.	Seismic Activity	10. -5
11.	Biology	11. -5
12.	Environmental Impact	12.

Group Memory - Boston Meeting
March 21, 1984 - Afternoon Session

4. Geology

Must be able to charact. the geology of the site. Prefer site be "simple" geologically.

Soil chemistry.

Fracturability of the rock: a. Existing fract.
b. Integrity of rock

Charact. water migration through layers of rock.

Permeability - avoid depending on perm. rock.

Ion - retention (exchange) capability of soil or rock.

Rock dissolution.

Vulcanism should be charact.

Avoid erosion, slumping, landslides.

Geothermal activity.

10. Seismic Activity

Soil liquification.

Fault lines.

Existing data should be scrutinized, but must go further.

Stay away from underground structures which might lead to disturbances.

5. Land Use

Site should be compat. with adjacent land uses

Avoid preserved areas, endag. species habitat, hist. sites, archeol. sites.

Compatib. with local land use plannings.

Avoid densly populated areas.

Prox. to major highway routes is important.

Avoid areas where wild and scenic rivers have been designated.

6. Social Impacts

Minimize dislocation of pop. and businesses.

Charact. the carrying capacity of a local public service.

Proximity to transp. networks.

Group Memory - Boston Meeting
March 21, 1984 - Afternoon Session

6. Social Impacts (cont'd)

Impact on work forces and employment potential.

Social and pysch. stress on pop. needs to be addressed. Provide mech. for dealing with the stress.

Disruption of transp. networks and other infrastructure.

7. Natural Resources

Avoid areas of signific. energy or mineral potential.

Site must be cautious in reference to prime AG land.

Survey natural resources of potential value.

8. Monitor

Avoid locationg near a facility which could mask or distort monitoring activities.

Monitoring should be easy (device easy to use and verifiable) and replicable.

Site size should be adequate for redundant monitoring.

Site should lend itself to "passive monitoring."

Monitoring should be on and off-site

9. Aesthetics

Should not be visually insulting (compatib. with surrounding land use and size are imp. factors here).

Minimize noise for surrounding population.

Aesthetic consid. apply PRE, during and post.

11. Biology

Look at site for deep-burrowing animals.

Potential health impacts thru the biolog. chain needs to be estimated and areas of high potential impact should be avoided.

Compensation incentives, r.g. town monitoring.

Impact mitigation funds for community services.

(Under #6)

Minimize corrosion effects from environment on site.

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GROUP MEMORY -- BOSTON MEETING
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It was decided by the group not to use the Nuclear Regulatory Commission (NRC) criteria only but to consider other criteria which may be important or need to be emphasized within the Nuclear Regulatory criteria. There was some consensus that those criteria should also be included but the group wanted to be very careful to avoid having this idea being thought about as an endorsement for shallow land burial. The following pages are the verbatim recording of the facilitated session.

WESTON

GROUP MEMORY -- BOSTON MEETING
MARCH 21, 1984 - EVENING SESSION

Weston did not give appropr. consideration in its proposal to the criteria inherent in Chapter 503.

Discussion about whether to discuss all technolog. possible.

What constitutes "low level" waste?

1. Transportation
2. Existing state and local mandates must be followed (?)
3. Social impacts
4. Scenic recreation areas
5. Intrusion into dump site from outside sources, e.g., plants, animals, man, autos and airplanes (accidental/intentional)
6. Monitoring needs beefing up, e.g., visual monitoring
7. Physical size of site
8. How to deal with spills when and if they occur - tie into site characteristics
9. Should be located so wastes are retrievable
10. Criteria for soil charact.
11. Criteria for dealing w. catastrophic accidents
12. Meteorological charact. of Mass. should be noted. Chronic and catastrophic should both be charact.
13. Hydrology

PERF. STANDARDS

1. Protect the gen. pop.
2. Protect indiv. from intrusion.
3. Protect workers during operation
4. Provide for stability of site for 500 years

Disagreement with list - some already addressed adequately by NRC.

Group Memory - Boston Meeting
March 21, 1984 - Evening Session

1. Transporation

   Located as close to main waste sources as possible. Mileage involved in transport. should be minimized.

   Located so that no accident will adversely impact any transp. artery.

   Must be able to support access methods for a timely response to accidents.

   Minimized hazards of shipment.

   Seasonal fluctuations in traffic patterns.

2. State and local communities should not have override(?).

   No Fed. law that circumvents local option (?). DISCUSSION

3. Social Impacts

   Impact should be minimal on cultural and natural resources, e.g., wild and scenic rivers, wilderness, historic sites, critical habitats.

   To the maximum extent possible, those impacted have to be made whole. (More). Ex: financial compensation for loss of tax base. Ex: environmental mitigation.

   Keep sites away from major pop. centers and major seasonal pop. centers.

   Social impacts should be monitored.

5. Intrusion

   Avoid intrusion that brings waste off-site, e.g., contamin. of food chain.

   Physical intrusion which might damage facility, e.g., long-rooted plants, burrowing animals.

   Secure from human intrusion, accid., or intentional. Includes limiting future use of site, e.g., for mining, etc.

6. Monitoring

   Site should be accessible to facilitate detection of leakage from several vantage points. More than instrumentation monitoring is needed. (?)

Group Memory - Boston Meeting
March 21, 1984 - Evening Session

6. Monitoring (cont'd)

Gases produced need to be monitored. Soils to be monitored.

(Go back to bottom of page 2) - Disagreement that visual monitoring is necessary or desirable - negative. People don't need to be walking around.

Monitoring should not be limited to radiation. Should include: fire, water, release of hazard. chem., corrosion of container, etc.

Must monitor biolog. intrusion and outward migration of contaminated organisms.

Monitoring of cumulative effects.

Epidemiological monitoring.

Monitoring of cumul. effects of low-level exposure, e.g., spider worts.

Group is concerned that siting is diff. to address separate from design, etc.

Waste form should be non-biodegradalbe. We don't assume that this is forever.

7. Physical Size of Site

Acreage must accom. both physical plant and adequate shielding of wastes and monitoring area to the site boundary plus safety zone.

Visual aesthetics should be considered at site.

8. Dealing with Spills

Site should be hydrolog. and geolog. amenable to clean-up.

9. Retrievability (deals w/prevention of spill reaching ecosystem and temporary nature of storage). But also depends on hydrolog. and geolog. considerations (?). (J.D.) This should not be considered temporary storage.

10. Soil Charact.

Excess acidity and alkalinity.

Criteria to look at is permeability of soil - to assure prevention of migration

Ionization charact,., particle size and shape might be considerations. Compaction.

Group Memory - Boston Meeting
March 21, 1984 - Evening Session

13. Hydrology

Instead of 100-year floodplain, substitute 500-year floodplain. (would have to be developed).

At least 40 feet to seasonal water table. (Disagreement that spec. should be made site specific).

Minimize prox. to surface water (that might change course, for example).

Erosion, run-off - unacceptable. Run-off that causes erosion a no-no.

No site in groundwater recharge zone.

*Tectonic activity should be charact..
Vulcanism.

Study past hist. use of the site.